SMALL BODY TALES: A COMPARISON AMONG THREE POPULATIONS. D. R. Davis (PSI) P. Farinella (Univ. Pisa), and F. Marzari (Univ. Padova)

Three populations of small bodies are now known in the solar system — the asteroids, Trojans and Edgeworth-Kuiper Belt Objects (EKOs). These populations are of great interest for many reasons: 1) they formed in the early solar system and contain the signature of early solar system processes; 2) they are sources of other transient populations which can and do hit the Earth, namely short-period comets from the Edgeworth-Kuiper Belt (and possibly also from Trojans) and near-Earth asteroids and meteorites from the main belt asteroids; 3) these bodies are the remnants of materials that failed to form planets in their respective zones. These three populations allow comparative studies to discern similarities and differences and to explore reasons for these.

The similarities are striking among these three populations: 1) there are vast numbers of small bodies in all of these swarms — Figure 1 compares the size distribution for the three populations. 2) However, the total mass in each swarm is small, substantially less than one Earth mass, and much less than what is expected assuming a smoothly varying mass distribution in the primordial solar nebula. Also, if these bodies formed dominantly by accretion as is widely assumed, then the low mass density that is found today implies that the timescale needed to grow bodies as big as Pluto or Ceres is long compared with the age of the solar system. Hence, either there was much more mass in each of these zones when bodies were accreting there, or the standard accretion scenario is incorrect. 3) A large planet formed just adjacent to these bodies — Jupiter in the case of the asteroids and Neptune for the EKOs. It is widely (but not universally) believed that the formation of these planets may have interrupted the accretion process before a full sized-planet could form, leaving behind the debris that we call asteroids and EKOs. 4) Currently all the three populations are undergoing a disruptive collisional process that grinds down macroscopic bodies into small particles affected by non-gravitational drag-like effects, forms collisional families and injects some of the fragments into unstable resonant orbits. 5) Subtle dynamical mechanisms, including both mean-motion and secular resonances, are at work in all the three regions over time scales ranging from 0.1 to 100 Myr (and possibly more). 6) Both collisions and dynamical diffusion work to remove bodies from these populations, injecting them onto chaotic, planet crossing orbits. These two mechanisms work with about the same efficiency in the E-K belt, while collisions dominate in the asteroid belt and, in the Trojan case, the situation is intermediate. The reason for the trend appears to be related to how the efficiency of the two processes changes with heliocentric distance — both show increased efficiency but dynamical diffusion exhibits a stronger variation. Collisional injection is increasingly efficient when moving outward in the solar system because orbital speeds are lower but fragment ejection velocities are approximately constant. But dynamical diffusion is essentially nonexistent in the main belt, but quite common in the E-K belt, due to the longer dynamical timescales in the E-K belt. 7) In the inner solar system, there are the terrestrial planets orbiting interior to the asteroids. Whether or not there are substantial bodies (comparable to the largest EKOs or maybe even larger) orbiting exterior to the inner Kuiper Belt remains to be determined. If they do exist, they would further the symmetry between these two populations.

References: Farinella, P. and Davis, D.R. (1992) *Icarus* **97**, 111- 123; Menichella, M. et al. (1996) *Earth Moon & Planets* **72**, 133-149; Marzari, F. et al. (1996) *Icarus* **119**, 192-201; Marzari, F. et al. (1997) *Icarus* **125**, 39-49; Davis, D.R., and Farinella, P. (1997) *Icarus* **125**, 50-60.

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The size distribution of the mainbelt asteroids, Trojans and Edgeworth-Kuiper Belt Objects.

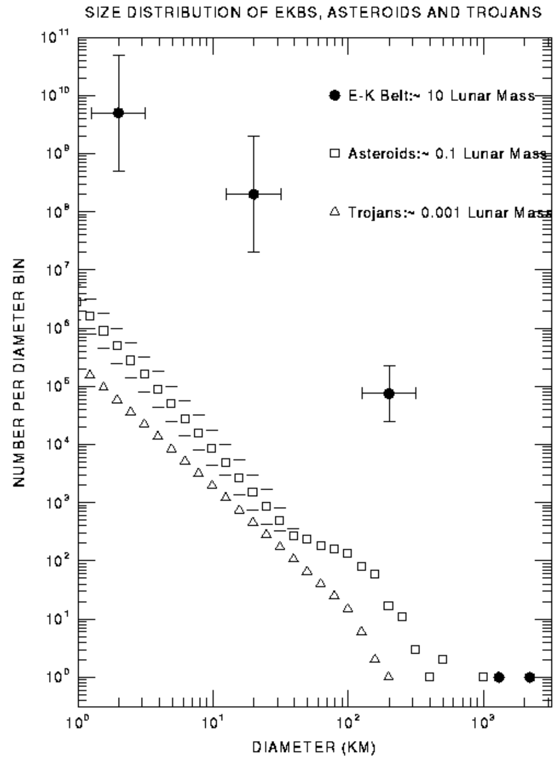

TABLE 1
A Comparison of the Major Collisonal Parameters for
Mainbelt Asteroids, Trojan asteroids and Edgeworth-Kuiper Belt Objects

The intrinsic collision rate follows Wetherill (1967) and gives the mean impact rate per unit cross-section per unit time for a typical mainbelt asteroid (times a factor π). The number of objects >1 km diameter are estimates from the available observational surveys. The collision rate is the actual rate at which a 100 km target body is impacted by a projectile 1 km or larger diameter. The loss rate is the estimated rate at which bodies larger than 1 km diameter are leaking out of the population due to being injected into resonances or chaotic regions of orbital element space. Data for mainbelt asteroids is from Farinella and Davis (1992) and Menichella *et al.* (1996), for Trojans from Marzari *et al.* (1996), and for EKOs from Davis and Farinella (1992).

Population	Mean Intrinsic Collision Rate ($km^{-2}yr^{-1}$)	Number of Objects >1 km (10^6)	Collision Rate (Myr^{-1})	Mean Impact Speed (km/sec)	Loss Rate (Myr^{-1})
Mainbelt Asteroids	2.8×10^{-18}	3±2	1/47	5.8±1.9	2,000
Trojan Asteroids	5.8×10^{-18}	1.5±1	1/66	4.9±2.6	1,000
EKOs	1.3×10^{-21}	10,000±5,000	1/30	0.5±0.3	200,000